Carbonization Conference.

REPORT OF THE DISCUSSIONS.

[Concluded from p. 128 of the March 7 Supplement to the "GAS JOURNAL."]

SESSION V.—Chairman: Dr. F. A. FREETH, F.R.S., F.I.C.

The concluding sessions of the Conference were held on Feb. 24 in the Queen's College, Birmingham—Dr. F. A. FREETH, F.R.S., presiding.

The CHAIRMAN, in apologizing for the absence of Sir Arthur Duckham, who was down to read the first paper on the handling, preparation, and utilization of gas-works coke, said that Sir Arthur was detained in America, but Dr. E. W. Smith would read the paper. Continuing, the Chairman said that, to the outsider reading the very able paper by Sir Arthur Duckham, it would seem that they were extraordinarily near to the solution of the problem of coke supply, but they did not seem to get there. As a layman it appeared to him that one of the reasons was that which was so strongly criticized in the paper—viz., lack of adequate propaganda. The paper showed that 40 million tons of coal were burned domestically and about 60 million tons by industry—*i.e.*, the quantities were not very different. Yet he wondered how many of the millions of householders who burned coal had ever seen a reasonable open coke fire going properly. Very few, he was afraid; but when they considered the way in which coke was slung at the public, compared with the immense amount of trouble which was taken with other commodities, one began to hope that, by suitable propaganda over a sufficient number of years, they might turn England into a smokeless country. Reading the paper, it struck him that they were very nearly there. What they had to do was to convince the man in the street. Not much effort had been made in that direction so far.

THE HANDLING, PREPARATION, AND UTILIZATION OF GAS-WORKS COKE.

By Sir ARTHUR DUCKHAM.

DISCUSSION.

Mr. JOHN ROBERTS said he would take for his text the following sentence in the paper: "Every gas showroom should include an example of hot water heating, and an open grate using coke," because he wished to give an illustration of the way some gas engineers and sales managers attempted to sell coke. This illustration was a personal experience of a friend of his who was a prospective customer for free-burning coke, which was being marketed by a gas company in a large city. The object was the replacement of about 3000 tons of raw coal with this coke, provided it was suitable. The prospective customer went to the gas company's showroom in the city, after making an appointment with the inspector; but when he asked to see a sample of the coke either by itself or burning in the showroom, he was told that there were no samples of the coke at the showroom, nor was there any grate showing how it burned. If these were the methods which were adopted in pushing the sales of coke, very little progress would be made. Incidentally, this same company had for two or three years issued a circular to the public, which was worded in such a way that it did not convey to the mind that the coke offered was intended as a substitute for raw coal. As he himself, an interested person, failed to appreciate this point from the circular, how could the ordinary man in the street be expected to be attracted?

DEVELOPING COKE SALES AT RAMSGATE.

Mr. R. H. RUTHVEN said he should not like it to go out that the instance mentioned by Mr. Roberts was the general attitude of gas companies in regard to the sales of coke. As a matter of fact, the particular undertaking referred to had been attempting to work without a chief engineer and general manager for some years, and this would explain the slackness which evidently prevailed in that large undertaking. It had been the attempt at Ramsgate to develop coke sales for a very long time. In fact, coke was graded and screened at Ramsgate before he was born. It was the fact that Ramsgate had not exported any coke almost for a generation; and this was due to many years of continuous work in attempting to educate the customers to the use of coke. A great deal had been said about the necessity for a low ash content in coke, and it had been suggested at a previous session of the Conference that undertakings should remove the ash from their coal. It seemed to him that it might be just as logical to argue that every gas consumer should purify his own gas. Obviously, it was impossible. The great majority of gas undertakings carbonized a comparatively small quantity of coal, and it was impossible for them to clean their coal before they carbonized it. Gas undertakings wished very much indeed to be able to obtain coal with a low ash content; but generally they met with the attitude that colliery owners wanted to sell their commodity without a guarantee either as to ash or as to moisture. Purchasers were compelled to take the coal as it existed, in obtaining a contract for coal in which was included a maximum ash content with a penalty clause. The figure was 10 p.ct. for a second-class Durham coal; and though this might be considered high, it was the lowest obtainable from the contractors. This question had been discussed at many meetings from time to time, and there were cases in which gas engineers had positively refused deliveries of large quantities of coal on account of the analysis being unsatisfactory. If it were possible, as an industry, to bring some pressure to bear on the collieries so that the inert material of the coal was removed at the colliery, some progress would be made. There was the other consideration, often previously mentioned, that coal had to be transported to the gas-works, and when there was a high percentage of inert material, apart from the native ash in the coal, there was necessarily a great deal of waste freightage involved. It was pointed out a year or two ago that there were something like 420,000 ten-ton wagons continuously employed carrying inert material from the collieries to various works; and this was a most serious waste of money and time. With regard to the sample of coke mentioned in the paper, there must have been a fire in the bunkers the day before, and he could scarcely believe that it was a fair average sample. Another point mentioned in the paper was regarding the production of free-burning coke, more or less a semi-coke; and the author referred to certain experiments. These experiments were carried out at Ramsgate with the assistance of Mr. Roberts and a representative of Sir Arthur Duckham's staff. The preliminary tests produced a fuel which burned almost as freely as coal in an open grate without the slightest alteration, and he felt there was a strong possibility of soon being able to provide free-burning smokeless fuel produced at high temperatures which would have the opportunity of displacing and meeting the competition of coal.

The CHAIRMAN asked whether a large proportion of the coke produced in Ramsgate was used in the district.

Mr. RUTHVEN said the latest figures showed that 80 p.ct. of the coke sales were for broken coke, used for domestic purposes.

The CHAIRMAN remarked that apparently the local housewives had been prevailed upon to burn coke.

Mr. RUTHVEN observed that for 15 years propaganda had been carried on in Ramsgate, and householders were provided with an addressed postcard so that they could order small quantities as and when they were required; deliveries being guaranteed within 24 or 48 hours.

The CHAIRMAN asked if Ramsgate was noticeably less smoky, as a result, than ordinary towns.

Mr. RUTHVEN said it was very noticeably less smoky than most other towns, as anybody who had been there would appreciate.

NEED FOR CONCERTED ACTION.

Mr. E. G. STEWART (Gas Light and Coke Company) said there was a point upon which everybody at the Conference would agree, and this was that the solid residue of carbonization was a suitable substitute for some of the 40 million tons of coal now used for domestic purposes. The production of that quantity of coke would, of course, necessarily result in the simultaneous production of gas and tar; and means must be found for the disposal of this gas and tar. Undoubtedly gas undertakings were in the best position to operate any of the processes. During the visit to the Birmingham Gas-Works on the previous day, it was seen what progressive undertakings to-day could do by the selection of their coals, by the careful selection and arrangement of their plant and carbonizing processes, by grading, and also by intelligent salesmanship. The idea had too long existed in the minds of, at any rate, a large number of the general public that coke was only a glorified form of cinders. Fortunately, however, the development work in connection with coke was throwing more and more light upon the matter every year; and this, together with propaganda, was undoubtedly bearing fruit. There were other forms of coke than gas coke; and all the various industries concerned were equally convinced that their coke was quite suitable for domestic purposes. The point, however, for each industry was to see that their coke was placed upon the market in such a form that it could be easily burned and handled by the consumer. Otherwise a good deal of the propaganda work already done by the gas industry would be spoiled because coke as a whole would get a bad name. The trouble was that with certain gas and other undertakings the sole idea seemed to be to get rid of the coke at all costs, and not to see that it was sold to the consumers in a form which was appreciated. It seemed to him that that was the point Sir Arthur Duckham had in mind in the last paragraph of his paper,

although he did not express it, and it was a matter which should be emphasized very strongly.

WEEKLY SUPPLIES OF SMALL QUANTITIES.

Dr. A. PARKER said there were one or two points which he thought ought to be stressed in regard to the question of preparing and marketing coke for use in domestic grates. As regards systems of carbonization, the tendency at the present time was undoubtedly towards completing the process in as short a time as possible. This was a move in the right direction, because there was no doubt that if coke were left in contact with methane and similar gases evolved during the last stages of carbonization, its combustibility and reactivity were largely decreased by deposition of carbon. As regards the use of coke in the domestic grate, more might be done in convincing the householder that only a slight modification of the ordinary grate was required to burn coke satisfactorily. Unfortunately the tendency in grate development had been in a direction the reverse of that required for burning coke. The shallow grate, so common nowadays for burning coal, was the wrong type for burning coke to the best advantage. There were, however, simple modifications which could easily be fitted, and the public ought to be better informed on this point. This was one direction in which propaganda could go. Another point was that many of the houses built in recent years possessed very little storage accommodation for solid fuel—and this was a serious matter. Coke occupied a larger volume than an equal weight of coal. Gas undertakings and others supplying coke should, therefore, institute regular weekly supplies of small quantities. There were a number of small middle-class houses in Leeds in which storage accommodation could not be more than 5 cwt. of coal, or approximately 3 cwt. of coke; and if there were trouble in getting frequent deliveries of small quantities, it would retard the development of coke for use in domestic fires.

UNIFORMITY ESSENTIAL.

Dr. E. W. SMITH said that this was a subject which must be looked at from two points of view—that of the gas engineer and that of the consumer. A great deal had been heard about complaints against coke in some districts, and Sir Arthur Duckham had indicated one particular complaint while also giving evidence that improved coke was available later; but it must be recognized that the major bulk of the coke that was made in the British Isles was satisfactory. In cities such as Birmingham, Sheffield, and London, the coke, for the greater part, was collected, graded, and quenched reasonably well; and in Birmingham, for instance, he understood they had no difficulty in selling the whole of their huge make of coke in their own district. Sheffield, he believed, was in the same position. The coke had been standardized as regards its method of production, and Sheffield found that if they happened to have coke just outside the standard, it was difficult to sell, because it did not happen to conform with the requirements the consumer had got used to. Therefore, it seemed to him that, while it was not possible to say that any particular method of carbonization as such was preferable to any other method of carbonization from the point of view of coke sales, it was necessary that there should be uniformity, and if uniformity could not be obtained, then it was necessary to have such an organization in each gas undertaking that each consumer in the district could be provided with coke from the same works all the time. Clean coal was required, but he did not think anyone would suggest that gas undertakings should start cleaning their coal. By co-operative demand and co-operative effort, however, it should be possible to insist and make it worth while for the collieries to clean the coal. There was a big development in this direction at present, and collieries were putting down at great expense cleaning processes which would enable gas engineers in the future in many places to have cleaner coal. Gas engineers in the main had not appreciated the importance of coke as an asset in assisting them to reduce the price of gas; but when one realized, looking at another side of the thing altogether, the improvement of the fuel used in heating retort settings, which meant improvement in the residue that was left, it would be seen that this had a bearing on the cost of gas. An improvement in the quality of the fuel used might mean anything up to seven times the value of the whole of the labour entailed in making the gas; and 0·5 or 1 p.ct. saving in fuel meant a great deal more than the saving of one man in the retort house. Therefore a little extra labour in the retort house, assisting in the reduction of fuel consumption, was well worth it. He therefore put it to gas undertakings that it was frequently the case that if an engineer asked for a little extra labour he was looked at askance; but if the selling side wanted an extra fifty men for mantle maintenance, or anything else, they were readily obtained. One effort was in the direction of trying to sell gas which was not cheap enough, and the other was in the direction of trying to reduce the price of gas. If it were a fact—and it could be shown to be a fact—that fuel was worth seven times the labour entailed in making the gas in the retort house, then it was obvious that anything that could be done to improve the quality of the coke, which improved the price of coke or stimulated the demand for coke, was going to have a very big bearing on the price of gas. Therefore, too much could not be said of the importance of coke to the gas undertakings as regards quantity, quality, and price obtained. Some point had been made about the lack of storage in modern houses. Older houses, however, had plenty of storage, and it was these houses in which old types of grates were found very largely, and these older types of grates would readily burn suitable coke. In the newer type of house the question of storage was being got over in the South, at any rate, by the use of small galvanized, specially constructed coke bins which could be kept in the yard or passage outside the kitchen door. They were perfectly weatherproof, and had a capacity of about 3 cwt. of coke. Gas companies could readily provide for a delivery weekly of small quantities of coke. This was being done, and could be extended. As regards propaganda, he did not know whether it was heresy or not—he assumed that it was not—but no good would be obtained by gas engineers looking to the British Commercial Gas Association to further the sales of coke, any more than they could expect that organization to further the sales of sulphate of ammonia or benzole. It was necessary for gas engineers to get together with the coke oven people, and have a separate organization for the sale of coke. It would not be practicable for the coke oven people to come together with the gas industry through the "B.C.G.A.," because their interests were different. It would, however, be a workable scheme for gas engineers at any rate to start talking about it, and start exploring what could be done with regard to the preparation and selling of coke through a separate organization. They knew what the troubles were, and they knew that some large undertakings had been in the habit of dumping coke outside their own districts. It was known that large undertakings outside London had occasionally had to dump coke in London. It was also known that undertakings outside London were able to dump coke in London and sell it at a net return equal to the price obtained in London, because, owing to the huge quantities made in London, it had been necessary to sell coke in the past at a low price. All these difficulties would be overcome if the gas industry recognized that they were not a set of (say) 800 or 900 individual undertakings, but one industry, and that anything that one of those undertakings did, whether for good or bad, affected the whole industry. It had already been pointed out that Birmingham was making first-class coke. This helped towns round Birmingham if those towns were prepared to make an equally good coke. On the other hand, it was possible for a small town just outside Birmingham to do Birmingham a great deal of harm by supplying rubbish to consumers who normally wished to get their coke from Birmingham. He put it to the industry that the whole attitude towards this coke question among individual undertakings must be changed, and there must be a complete recognition of the socialization of coke sales, because until that was done there would be very little advantage in propaganda.

Mr. G. J. GREENFIELD said the point he wished to bring up was that in order to make coke popular with the public it must be supplied in such a form that the coke fire could be poked, because until that was possible it could not be sold to the average housewife in this country. In his own house he could burn coke in ordinary grates satisfactorily if he were left to it alone, and his wife and maid were out of the way. When, however, it was left to his wife or maid to see to the burning of the coke, they simply would not bother with it, and complained that they could not poke the coke fire. He believed that was representative of millions of housewives in this country, because it was regarded by them as a great disadvantage that they were advised not to poke the coke fire.

Mr. R. H. RUTHVEN said he did not think Dr. Smith's suggestion that fuel cost seven times the total labour entailed was accurate. In his own case it was about four times.

Mr. R. WATSON (Doncaster) said he would like to remove the feeling that might possibly arise as a result of Dr. Smith's remarks that the gas industry was lacking in the consideration of methods for the sale of coke. It was true that no co-operative movement had been started, but throughout the country sections had been established which dealt with commercial matters in the respective areas, and the sale of coke had been, and was being, continuously studied. Stress had been laid upon the necessity for grading, preparing, and cleaning coke; and he only wished to say that the arguments in favour of such methods had been considered, and they were adopted by many gas undertakings with success. The gas industry was not apathetic, and what was required was an extension of these efforts throughout the country.

COST OF CLEANING COAL.

Mr. R. RAY said that, as one interested in the coke oven industry, he agreed that the cleaning of fuel was essential in view of the fact that the coal used in the coke oven industry was considerably inferior to that usually carbonized in gas-works. The fuel for gas-works also had to be transported over considerable distances, and the cost of transporting dirt was considerable. If, on the other hand, gas-works fuel was cleaned at the colliery, where it ought to be cleaned, then there was also the cost in transporting a certain proportion of moisture. In any case the cost of cleaning gas-works fuel would have to be added to the price of the fuel delivered at the gas-works. That might amount to anything from 1s. 6d. to 2s. 6d. per ton. The difficulties in cleaning the slack used in coke oven practice were increasing in many parts of the country owing to the ever-increasing percentage of fines. Elaborate apparatus for cleaning this material has been adopted in many instances, but it was a sorry thing to have to admit that a corresponding increase in the price of the cleaner coke was not obtained. Was it therefore a certainty that if the gas-works people cleaned their fuel, as coke oven people did, they would get a corresponding return for their final product? He doubted it very much. It was held on the coking side that they got too low a figure for their furnace coke to-day. It was certainly a lower figure than gas-works usually obtained for their coke; and if the gas-works were not going to get a corresponding increase in price for their cleaner coke, the extra cost of washing their coal would have to go on to the price of gas. If the gas was going to cost more, then he suggested that this fact opened a wider field than ever for coke oven gas. In the Sheffield area, without propaganda and without pressing the product on the domestic market, there was an ever-increasing demand for coke oven coke. During the past twelve months his own firm had graded for the first time the domestic fuel from its coke ovens by request rather than by pressing it upon the consumers. He admitted that to-day, in view of the antiquity of the coke oven plants, the coke produced was not so good as gas-works coke. In fact, it was decidedly unsatisfactory. However, as was known to many, a start had been made to put down what would be the largest coking plant in the country, and special provision had been made throughout for the production of a first-class domestic fuel. The battery bin had a separate compartment for dealing with clean washed peas and nuts; and judging from experiments which he had carried out during the last few years in a modern high-temperature comparatively narrow oven, a suitably washed pea or nut fuel enabled the production of a coke containing

4 to 5 p.ct. of volatile matter with an open texture which burned easily in the open grate. Moreover, the ash content of that coke did not exceed 4 to 5 p.ct. These remarks might give encouragement to his friends on the other side of the industry who might be doubtful as to the value of cleaning their coal from the point of view of coke sales; but unless they wished the coking industry to make still further inroads into that important market, they would have to do the same thing.

Mr. H. J. TOOGOOD (Elland) suggested that the point made in the paper as to grading coke might be carried a little further. Standard meshes might be used. For instance, if the factor ¾ was used, this could be standardized to indicate under a 2 in. diameter hole and over a 1 in. diameter hole. Some such system would have a great effect upon standardizing coke and facilitating sales.

[Sir Arthur Duckham has since replied in writing to the discussion —see p. 144.]

BLENDING IN THE GAS AND COKE OVEN INDUSTRIES.

By JOHN ROBERTS.

DISCUSSION.

Mr. E. C. EVANS said he had not anticipated taking part in this discussion, but Mr. Roberts had mentioned in the course of his introduction that he was surprised to hear during the discussion on his (Mr. Evans') paper during the Conference that the terms of reference to the Research Committee of the steel industry did not include the temperature of carbonization of coal. As a matter of fact, this was not the case. What was said was that the terms of reference in regard to his paper, which was a progress report up to date of the work that had been done, did not include the question of temperature of carbonization. This matter was being taken up by the Scottish Coke Research Committee. The question was one of very great importance with coal of comparatively low coking index—a type of fuel common in Scotland—and the matter was being gone into fundamentally. The point mentioned by Mr. Roberts as to Koppers' suggestion that blast-furnace coke should be carbonized at from 600° to 800° C. was a most interesting one. Mr. Roberts specified in his paper four requirements for blast-furnace coke. He was not in agreement with the requirements that blast-furnace coke should be combustible and at the same time resistant to the excessive solvent action of CO_2 in the upper regions of the furnace. That point had been raised over and over again by blast-furnace operators. Sir Lothian Bell mentioned fifty years ago that all coke which was reacted upon readily by CO_2 was a coke of poor blast-furnace quality. This was generally the case, but not because of excessive solution. The Iron and Steel Manufacturers' Research Committee had analyzed about 150 operating records of blast furnaces practically throughout the world with coke consumption varying from 15 cwt. to over 30 cwt., and had found that there was a constant loss, as far as could be seen, of coke due to the action of CO_2. What apparently happened was that there was a series of balanced reactions, and when carbon was acted upon by CO_2, the CO produced reacted on the ore in the higher region of the furnace, which in turn diminished reduction or solution in the hearth zone, so that ultimately a balance was obtained. Therefore, from the point of view of solubility in CO_2, he did not think the point made by the author was of very great importance. This, however, as had already been pointed out, did not imply that soft cokes which were readily reacted on by CO_2 were good for furnace use, because it was a function of physical character apart from reactivity. The other point he wished to mention was combustibility in relation to the proposal of Dr. Koppers that blast-furnace cokes should be made at a temperature from 600° to 800° C. Why? Was it because of the increased combustibility that would result? Was that Dr. Koppers' explanation? He believed this was the suggestion in Dr. Koppers' paper; but the Research Committee had failed to find any relation between combustibility and blast-furnace fuel economy. On the other hand, he was not sure that Dr. Koppers' suggestion was not worthy of investigation, but on entirely different grounds. Coke that had been exposed for a considerable time to a high temperature contracted. Its apparent specific gravity increased, and while Dr. Braunholtz had pointed out during the Conference that porosity might not differ very much, the pores became very much smaller. When carbonizing at 600° to 800° C., a coke was obtained of low apparent specific gravity. In blast-furnace practice coke was charged into the furnace by volume. Frequently a skip full of dense coke of high specific gravity weighing more than a skip full of lighter material would result in a higher gross weight of coke used at the end of the month, so that it was possible with a lighter coke sufficiently strong and hard to withstand blast-furnace conditions to obtain better fuel economy. Such a coke could be produced by blending, and might be of service to the blast-furnace operator. From this point of view the question was one worth investigation; and if Mr. Roberts, or Dr. Koppers, or anybody else who was interested in coking operations throughout the world could produce evidence of improved results by the use of a coke of that type, it would be a considerable service to the industry in this country.

WORK AT LEEDS.

Dr. A. PARKER said that, though Mr. Roberts had referred to some work which he and his colleagues had had the privilege of carrying out for the Institution of Gas Engineers, and had made a brief statement of the results obtained, this statement considered alone might lead to wrong conclusions. Mr. Roberts had stated that it had been shown that by-blending with coke breeze, larger volumes of gas for the same weights of coal were obtained from coal-coke mixtures than from coal alone, at all stages of carbonization. While accepting this statement, Dr. Parker said that it was definitely concluded that, though an improvement in gas volume for a given weight of coal had resulted, the volume occupied by the charge of a given weight of coal plus the added coke was so much greater that the capacity of the retort was considerably reduced. For that reason, with the particular coal and coke used in those experiments, it was not felt advisable to recommend the blending of coke breeze and coal. He and his colleagues, however, were careful not to make that conclusion general, because with some coals it might be a distinct advantage to blend with coke. They did not know definitely as far as other coals were concerned, but with the particular coal and coke they used the disadvantages more than counterbalanced the advantages. He wanted to make this point perfectly clear. Referring to the work of the Institution of Gas Engineers and other workers, Mr. Roberts had stated that in both cases the rate of gas evolution was increased by separating out the fines. This statement he was prepared to accept. The statement "blending with inerts," however, seemed somewhat vague. Coke, in some measure, might be considered as inert. The other substances added to the coal before carbonization were of a different type. Sodium carbonate, calcium carbonate, and iron oxide were added in amounts equivalent to two parts of the corresponding oxides of these compounds to 98 parts of coal; and in these instances increased rates of gas production and larger yields of gas by volume and in therms per ton of coal carbonized were obtained. In the case of sodium carbonate, the total gas volume, when the coal was carbonized with the temperature of the retort over 900° C., was 24 p.ct. more per ton of coal than with coal alone, and the thermal yield was 12 p.ct. more. In these cases, however, he rather hesitated to call the added compounds inerts, because he believed they influenced the mechanism of carbonization in some way. With the addition of sodium carbonate, he believed that the moisture, ordinarily distilled from the coal undergoing decomposition in the centre of the charge, passed over coke already formed on the outside of the charge; and since that coke was more reactive towards steam, water gas was produced. He was not yet in a position, however, to say why that coke was more reactive towards steam than coke obtained from coal alone. Experiments were being carried out by the staff of the Institution of Gas Engineers and by Prof. Cobb and his co-workers at Leeds, but a fundamental explanation of these facts had not yet been reached. He was pleased Mr. Roberts had referred to the increased rate of gas production which resulted from the screening of coal. In this connection he would like reference also to be made to the work which Mr. Rhead carried out at Birmingham with continuous vertical retorts. Mr. Rhead also found that a greater throughput of coal was possible in a continuous vertical retort with coal of a graded size and fines removed, as compared with a mixture of different sizes, and thereby a greater gas production was obtained per retort in unit time. In discussing this subject, a good deal had been said about combustibility, reactivity, and similar properties. In the present stage of research in carbonization and coke production, there was some idea of what these terms meant, but they were vague ideas; and he was hoping that in the next few years progress would be made which would enable a clearer conception of the terms relative combustibility, reactivity, and ignition temperature.

BLENDING AND FREIGHTAGE.

Mr. R. RAY said the subject of the paper was one which they were endeavouring in South Yorkshire to appreciate, because, as was well known, South Yorkshire furnace cokes were somewhat inferior to those produced in South Wales or Durham. He referred especially to the physical properties of the cokes. On his own plants some experiments were carried out a little while ago using anthracite duff and coke breeze, and some remarkable results were obtained. One of these experiments was referred to by Mr. Roberts, in which 15 p.ct. of this anthracite duff was used, with the result that a 9-ton charge of coke was pushed out of the oven in one solid block. The anthracite duff was then systematically reduced in proportion, and at 5 p.ct the coke produced maintained an open texture and was very vastly improved from the point of view of physical strength. Needless to say, he did not inform the blast furnace department of what he was doing; the man responsible for the production of the coke—himself—usually being the butt for all the unsavoury epithets which the blast furnace men could summon up. This time, however, he actually got a congratulatory letter from the blast furnace manager, saying that this was the most wonderful coke he had ever had. Unfortunately what held up blending in the coking industry, and certainly in his own case, was the cost of transport. If they were on the seaboard or near any of the inland waterways, which could bring certain types of slacks from Derbyshire, for instance, or even a clean anthracite duff from South Wales, the position would be different. But in present circumstances the whole question was uneconomical, and until reasonable railway freights were obtainable, the experiments, which had been sufficiently successful to warrant blending being carried out on a large scale, were absolutely impossible in practice. On several previous occasions he had referred to the freight question, and it was a very serious one indeed from the point of view of the coking industry. For instance, his firm's new works which were just being erected were roughly 1½ miles from the blast furnaces, and the cost of transport of coke by rail was in the neighbourhood of 1s. 7d. per ton for wagon hire and freight, while the anthracite duff, which probably was worth 3s., 4s., or 5s. per ton at the pithead in South Wales, cost 20s. delivered, owing to the freight.

BURNING COKE IN DOMESTIC GRATES.

Dr. W. T. K. BRAUNHOLTZ (Armstrong College, Newcastle-on-Tyne) pointed out that in the work of the Coke Research Committees, factors such as temperature of carbonization were not being lost sight of. In fact, very complete records were being kept not only of temperatures of carbonization, but of other factors such as size of oven, time of carbonization, complete analysis of the coal, &c. The mere fact that data on these points had not been published did not mean that these points were not being examined. He felt that perhaps too much importance was being attached to combustibility as applied to domestic fuel. The object of burning fuel in the domestic grate was to produce heat as economically as possible. He was not a mathematician, but he understood that the heat radiated

from the hot body was proportional to the fourth power of the absolute temperature of that body. Therefore, to get the maximum heat radiation from a fire, it must be at a high temperature. From work that had been done so far, there was an indication that the highest temperatures were produced from cokes which were least reactive to CO_2. Beehive coke, for instance, was proverbially hot, hard and non-combustible; and if it was compared with a soft coke, and given equal volumes of air, it would be found that the temperature produced in the beehive coke was usually higher than the temperature produced in the soft coke. Therefore, presumably, if sufficient air could be supplied in the domestic grate, a better radiation efficiency would be obtained from a sparingly combustible coke than from an easily combustible one. With regard to the suitability of grates for domestic coke, he suggested that perhaps too much time was being spent in trying to produce a domestic fuel which would burn on existing and old-fashioned grates, and that it might be better to spend a little more time in producing grates to burn coke scientifically. At the British Industries Fair there was a type of coke fire in which the air was drawn in at the front, so that the maximum radiation was produced where it should be. He ventured to think that in a grate of that sort not only gas coke, but relatively non-combustible coke could be burned. How many gas companies in this country were there who supplied coke fires on hire? Before consumers could be expected to use gas coke regularly, it would be necessary for the gas undertakings to hire out to consumers grates suitable for burning coke. As regards Mr. Ray's remarks on blending, there were very few districts in this country where high-volatile coals existed in close proximity to low-volatile coals; but, as was pointed out in the paper, they might look with profit to the experiments that had been carried out in Upper Silesia, the high volatile gas coals of which gave, when carbonized by themselves, distinctly inferior cokes from the blast furnace point of view. It had been found, however, that, by blending the coke with a semi-coke produced from the same coal, a very much improved product was obtained. He would not go into the economic aspect of it, but it seemed that there was a distinct possibility that, where it was impossible to import low quality coals, it might be possible to produce on the spot a low-volatile semi-coke suitable for blending from the same coals which were being carbonized for coke or gas-making purposes.

Blending Coal with Coke Breeze.

Mr. J. B. Deakin said he had had some experience with the mixing of coke breeze for the production of blast furnace coke, and the chief points in regard to producing a hard tough coke were in the mixing, and more especially in the grinding or crushing of the mixture. Some years ago he carried out a test on a coke oven plant, adding 3½ p.ct. of coke breeze. He was coking a good quality South Wales coking coal with 25 to 27 p.ct. volatile matter, and the breeze was mixed in careful proportions on the conveyor feeding the crusher from which the coal was lifted to the service bunker. Speaking from memory, he believed the size of the crushed coal was 65 p.ct. through ½-in. mesh, and the result was bad. The coke was sandy, and much more friable than the usual make of coke in the plant; and he did not go on with the experiment. He had coked, on a small scale, breeze and coke mixtures that were crushed far below the economic limit, actually through 200 I.M.M. mesh, using 50 p.ct. of coal and 50 p.ct. of crushed breeze. Testing that mixture in 1 cwt. quantity, a coke was produced that gave an oversize on the tumbler test of over 90 p.ct.—the coke being absolutely hard and the pores very small. He had been interested in Mr. Ray's remarks as to mixing anthracite duff, because he had done a good deal of work in that direction, using 10 p.ct. up to 12½ p.ct. of anthracite duff. With a coking coal which produced a very hard, dense coke he did not get the large differences mentioned by Mr. Ray. These tests, however, were carried out some years ago, and he had not the apparatus for testing physical strength which was now available. That coke was not tested out on the blast furnace by itself, but it was used in conjunction with 50 p.ct. of other coke; and the blast furnace manager reported that he saw no difference, either for better or for worse, in the result. There were a few points which might be interesting in connection with the use of anthracite duff. Owing to the lay-out of the works, to get good mixing and use it economically, it was necessary to pass the duff through a washery along with the ordinary coking small coal; one wagon of duff being used to eight or eleven wagons of other coal. After the fuel was crushed and carbonized, it was possible to see the anthracite in the coke. The mixing was very efficient, though no special measuring devices were used. One of the disadvantages was that, owing to the anthracite duff being very small, there was a considerable thickening-up of the washery water, and after a time it became necessary to sludge the slurry cone before a start could be made in the morning. Another drawback was that, owing to the fineness of the anthracite, it held water longer in the draining bunkers, and the moisture content of the coal going into the ovens was increased from 9½ to 11 p.ct. It therefore made a considerable difference to the coking time. One per cent. of moisture could usually be reckoned upon as adding one hour to the coking time; and where a maximum production was being worked, this made a considerable difference. He supported Mr. Ray in his remarks as to how uneconomic it was to import anthracite duff to distant parts from South Wales, owing to the freight charges. Even though his own plant was situated in South Wales, it was on the eastern side of the coalfield, and it cost 8s. 6d. per ton freight charges on top of the 3s. 6d. per ton for the coal at the pithead, making a total of 12s. per ton delivered.

Mr. E. G. Stewart (Gas Light and Coke Company) referring to the statement in the paper regarding the heat energy put into the producer for heating the retorts, taken from Mr. Hardie's paper before the Institute of Fuel—viz., 4·2 therms per hour energy input—said this must not be taken as the final figure, because 0·9 therm was recovered in the waste-heat boiler, which brought the figure down to 3·3 therms. Moreover, the diagram in Mr. Hardie's paper showed that the heat input to the setting, after allowing for losses in the producer, was only 2·3 therms. Though this did not upset the general argument put forward by Mr. Roberts, it did affect the period when the carbonization of the charge became thermally uneconomical.

Carbonizing Coals without Fines.

Mr. T. F. E. Rhead said there were two advantages in working the coal with the fines taken out. One was the sweeter working of the retort, owing to the opportunity for the coal to swell internally, and the other was the internal heating effect through the hot gases passing up the centre of the charge, which they could not do when the fines were allowed to remain in the coal. As with most advances, however, there were some drawbacks; and the fact that there was more internal heating meant that there was more low-temperature carbonization at the top of the retort. This was evidenced by the increased amount of tar which was obtained with a very open charge. This, however, was more than counterbalanced by the increased throughput which was obtainable with sweeter working and a quicker carbonizing charge. The gas obtained, also, was greater in thermal yield per ton, but it was of a lower quality, due to the fact that the steam had a better opportunity of mixing with the coke and getting more cracking surface. In connection with the working of continuous verticals with coals blended with coke dust, he believed that gas engineers appreciated that they might have to come to some compromise in producing a better quality of coke, and it might be that they would not get so much gas per ton. He was not yet convinced on this point, but he had carried out several full-scale experiments, briquetting blends of rich gas coals or moderate gas coals with up to 25 p.ct. of coke dust; and he could not find any evidence that there was an increased thermal yield of gas per ton, calculated back on the coal. The evidence was rather that there was a reduced thermal yield of gas; and he was wondering whether the quicker heat penetration which was obtained through mixing coke dust might not cause a greater cracking of the hydrocarbons passing out from the carbonizing charge. If anybody had any evidence of this, it would be extremely valuable in carrying out further tests.

Mr. P. C. Pope (Secretary of the Institute of Fuel) said that one point which occurred to him, arising out of the papers by Sir Arthur Duckham and Mr. Roberts, was why the gas industry and the coke oven industry had not devoted a little more attention to a method of increasing sales of coke by endeavouring to produce a cheap and simple piece of apparatus which could be adapted to existing grates in houses, to enable them to burn coke efficiently. A large number of people were anxious to burn coke (whether gas coke or oven coke did not matter as long as it was properly graded) in their existing household grates, but who would not go to the expense of putting in new grates because, being leaseholders, the fitments would eventually belong to the landlords. However, he believed that a cheap piece of apparatus for fitting in existing grates would find a ready market. There were one or two such appliances in a very crude form. If the industry generally got down to the matter, and devoted some real care and thought to it, he believed something could be devised which would have the effect of very greatly increasing the sales of coke.

The Chairman said he had been very much struck by the different way in which various speakers had handled the domestic use of coke. Some had seemed to regard it as a logical problem, which it ought to be, and others regarded it as a sentimental problem, which it was. It was no use preaching to the public that they ought to do this and that logically. They would not, and his sympathies went out to the coke-poking gentleman. [Laughter.] He believed the solution of that difficulty would lie very largely in a newspaper slogan. Another point was that one speaker said he had been making experiments which he admitted were outside any possibility of a practical result. He was grinding coal extremely fine, but it occurred to him (the Chairman) that the results obtained would afford a very good pointer for the future. It did not call for him, who knew nothing about the industry, to criticize in any way, but he had a feeling that something would come in the future from experiments which were conducted upon frankly uneconomical lines, provided they were not done on too large a scale. In other words, they would get to know a little more about the final question, and what possibilities there were. Blending had been discussed; and it occurred to him that, if coal was heated slightly, it could be turned into something which would blend. A great deal had been said about freights; and it certainly was distressing to think that industries were tied up in such a manner. Therefore, investigations into the possibility of using the same coal, heating it slightly, and turning it into something that would blend seemed a promising field for investigation.

The Author's Reply.

Mr. Roberts, replying to the discussion, said he was very glad to learn from Mr. Evans that the terms of reference to the Coke Research Committee did include the temperature of carbonization. As regards the solvent action of CO_2, it was the *excessive* solvent action of CO_2 to which the paper referred. He did not intend to prescribe the properties of coke. Indeed, he thought the managers ought to lay down what the properties of coke should be, and it was difficult to get them to do that. Koppers and others since 1922 had proposed medium temperature carbonization, to which he had referred, for the production of blast-furnace coke. It so happened, however, that he himself had proposed practically the same temperature a year or so earlier, but not for blast-furnace fuel; it was for domestic fuel, and, of course, if the same temperature range was going to produce a domestic and a blast-furnace coke, so much the better. Dr. Parker had mentioned his experience in the blending of coal and coke, and pointed out that with the coal he examined he did not get an increased throughput. It did not follow that there would be an increased throughput of raw coal as the result of blending an inert material; but in the paper was quoted the case in which Mr. E. V. Evans had shown that, in spite of the fact that he had introduced 25 p.ct. of inert, he got an increased throughput of raw coal. This was quoted as against an opinion expressed elsewhere, without experimental evidence in support, that the throughput would be re-

duced. Dr. Parker had also referred to the work carried out by Mr. Rhead at Birmingham, which he himself had dealt with in another place; and he regretted that he had omitted to mention it in the present paper, because it had a bearing on the prospects of blending in continuous vertical retorts. In the paper it would be noticed that he had confined blending without briquetting to static retorts. There was very little advantage in blending without briquetting in continuous verticals, though he believed it had been shown that there were certain advantages, especially with regard to the production of the amount of coke required, if the blends were briquetted and then carbonized in continuous verticals. Efficient blending demanded finer crushing than was desirable in continuous verticals.

Mr. RHEAD said he wanted to confine his remarks to blending with coke dust. He had carried out no tests on coal blending, when quite a different effect was obtained.

Mr. ROBERTS said that one reason why he did not fancy the chances of success in continuous verticals was that the binding material functioned at a given moment, and just at that moment the charge might be moving, and the particle of coal with which it was going to combine might be displaced, and become imperfectly cemented. Therefore, there must be a static charge if that process was to function properly. Mr. Ray had given some interesting information with regard to his experience with anthracite dust, and had raised the transport question. The question of the transportation of non-coking coal to an area where only coking coals were met with, or *vice versa*, he had referred to at a previous conference at Sheffield a few years ago. A gas engineer on the east coast had asked him where he could draw his non-coking coals from. He was drawing his coking coals from Durham, and would it be proposed, he had asked, that he should draw his non-coking coals from Yorkshire or the Midlands, and pay a higher freight than he was paying on his coking coals? It appeared that this gas engineer was getting his coal from a certain colliery in which three seams of coal covering a vast area had always been abandoned in the mine, because they were non-coking. They were so-called "cinder" coals; the ash content being 7 p.ct. and the volatile about 17 p.ct. These coals were not mined because they were non-coking, but they were in the same colliery. Therefore, he suggested to those interested that, if they would only look around, these non-coking coals might be found in unexpected places. Here, he could introduce the question of preheating. Reference had been made to Silesian products; and there, according to Bonnemann, they had taken semi-coke fines and mixed them with coking coal, with very satisfactory results, and had thus rendered themselves independent of coals which were formerly drawn from outside the area. The same thing had happened in the Ruhr. There they had used the "K.S.G." low-temperature carbonization process, and produced a certain amount of lump smokeless fuel for domestic use, and the fines were transferred to the coke ovens and blended with coking coal. This had enabled them to dispense with stamp charging. If non-coking coal was not available, it was thus possible to make it, and it could be done by preheating coals. This method had been proposed; and it was mentioned in the general review of low-temperature carbonization processes that Dr. Wheeler was carrying out experiments on a semi-large scale on these lines. That process was discovered by the staff of Low-Temperature Carbonisation, Ltd., in 1920, but unfortunately they did not go ahead with it. It consisted in reducing the binder of strongly-coking coals by preheating at a temperature from 100° to 300° C. in the presence of air. It had been published several times; and Wisner, of the Carbocite Company, of Canton, Ohio, was using that process for the production of semi-coke. The Heller-Bamag people, in Germany, employed a similar process, and they stopped at the stage when the binder was just sufficient to form a coherent coke. If it was desired to go further, it was possible absolutely to destroy the coking properties of the coal. This was definitely proposed in 1921—viz., to make an artificial non-coking coal. He had prepared blends which had been prepared from such coals, and the cokes could hardly be distinguished from cokes prepared from natural non-coking coals. He took Haigh Moor coking coal, and preheated half the charge at a temperature of 150° C. for half-an-hour in an oxidizing atmosphere. The coal would then no longer coke. He took that coal and mixed it with the same quantity of Haigh Moor untreated coal, and got a very satisfactory semi-coke at 750° which could hardly be distinguished from a Haigh Moor coke produced from a blend of Haigh Moor and Brodsworth non-coking coal. Therefore, it was possible to make their own non-coking coals if necessary. The process had been objected to on account of the two-stage heating which was involved; but when it was remembered that in the preheating process a good deal of the inert gases, such as CO_2, was eliminated, together with some of the water of formation, in addition to hygroscopic moisture, these inerts were not raised to a higher temperature than the temperature employed in preheating, and they were not passed through the condensing system. Therefore, the advantage might be sufficient to warrant the use of preheating. Generally, he preferred to employ the binders of coking coals than to destroy them.

On the matter of the temperature developed during combustion, mentioned by Dr. Braunholtz, who had stated that if one took a dense beehive coke, and gave it sufficient air, it was possible to get a higher temperature than with a soft coke for the same volume of air, he would point out that it was very much easier to get a high temperature with a semi-coke in almost any type of grate than it was to get that temperature with beehive coke. The temperature of a semi-coke fire at Ramsgate was determined with a pyrometer, and was 1100° C. This was obtained without any excessive draught. He could get the same temperature in his own "den" at home, on the bedroom floor, where he could not use an ordinary coke satisfactorily, and where he had only 18 ft. of draught. With regard to grates, he had come across hundreds of differents types at various times, and he must say that the tendency to introduce the shallow type of grate mentioned by Dr. Parker was to be deplored. They were unsuitable for burning coke satisfactorily. He consumed smokeless fuel at home as a householder, where he had several grates of the semi-well type. In some of them he could burn high-temperature coke, but the objection to these grates was that there were no bars in front, and there was difficulty in maintaining the fire satisfactorily, and of keeping the cinders from falling out. He had already had a "dig" at the gas companies over this matter of grates in a previous discussion; but here he wished to pay them a compliment, and refer to the grates that were displayed at the Fair. There certainly were grates available now eminently suitable for the use of coke and semi-coke.

Mr. Deakin had referred to South Wales coals. Though it could often be predicted what proportion of inert material was required with a coal of a certain volatile content, one could not always guarantee that the desired result would be obtained. In working with some Welsh coals—for instance, the 2 ft. 9 in. seam, having a volatile content of 22 p.ct.—if he mixed 10 to 14 p.ct. of breeze, he got a satisfactory coke. If he mixed 20 p.ct. of breeze, he got an unsatisfactory coke, and if he took 30 p.ct. of breeze, he got a very good coke. It was curious that somewhere in between some effect had taken place which interfered with the process, and resulted in the production of an inferior product. He believed others had had the same experience in blending non-coking coals in various proportions. Then there was the question of oven heats. Unless there was rapid heating of the ovens, blending was not likely to be effective, unless allowance had been made for this in the laboratory tests. Mr. Stewart had put him right on the matter of the therms put into the retort, and he was obliged to him for doing so. He had taken the figure mentioned in Mr. Hardie's paper for the heat put into the retort without, of course, making the allowances mentioned by Mr. Stewart. Mr. E. V. Evans used similar retorts, but did not give figures of heat input; but when he himself had spoken of the yield from the retorts or from the fuel in the later stages of carbonization, he was not referring to the Gas Light and Coke Company's experiments, but to Evans' experiments; and with his briquetted blend it was found that at the end of five hours he was not getting gas out at the rate of even 1·5 therms per ton, whereas normally it would take 9 hours with the same retort and a straight coal to extract the whole of the gas.

The CHAIRMAN, proposing a vote of thanks to Mr. Roberts and Sir Arthur Duckham, said it was always a pleasure to listen to authors who really knew what they were talking about. That certainly had been a characteristic feature of the two papers in question, and he thought the further thanks of the meeting were due to Mr. Roberts for the additional information he had given in his reply.

The vote of thanks was carried with acclamation, and the Conference adjourned till the final session.

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SESSION VI.—Chairman: Dr. F. A. FREETH, F.R.S., F.I.C.

A GENERAL REVIEW OF LOW-TEMPERATURE CARBONIZATION.

By F. S. SINNATT, M.Sc., F.I.C.

DISCUSSION.

Dr. W. CULLEN said that probably a breath of fresh air from one who had entered quite recently into the arena of low-temperature carbonization might be something new in a conference of this sort—particularly as within the last few months he had had an opportunity to go into the financial aspect of quite a number of these processes, as a corrective to the somewhat eulogistic reports which had appeared in the daily Press. Some of the reports which had appeared, especially in the financial papers, required a great deal of justification; and if he might paraphrase his own experience, he would like to say that nothing that he had seen in coal carbonization, whether looked at collectively or individually as regards each process, would justify the somewhat fulsome reports which had appeared in the daily Press from time to time. At the best, for what it was worth, he thought that those who were willing to embark money on such ventures as these, provided they were lucky in selecting the correct process, might look for a reasonable, but certainly not an extraordinary, return on the capital they invested. That was as far as he was prepared to go at the moment.

SOME DIFFICULTIES.

He was rather interested in Captain Sinnatt's classification; and although his own classification was not unlike that of the author's, he would like to give it for what it was worth. First there were those processes which depended upon internal heating which, concomitantly, also gave a large production of low calorific value gas and, naturally, a comparatively small production of semi-smokeless fuel. Then there were a very large number of systems in which the retorts were externally heated, and which seemed, although differing from one another, to have substantially the same principle—that the movement of coal was downward, very largely by gravity. This, as the author had pointed out, as a rule gave a comparatively small amount of gas of high calorific value; and the problem was the problem of how to utilize this high calorific value gas to the best advantage. The third type of process was that in which only pulverized fuel was used, of which Captain Sinnatt had given many examples. It might be useful if he mentioned the difficulties, as they appeared to him, connected with each of these classifications. There were first the Maclaurin and Midland Products systems appertaining to the first classification. The difficulty there was synchronizing the marketing of the semi-coke and the very large volume of low calorific value gas which was produced. He did not suggest that this was impossible; but to exploit these processes economically and to the best advantage would mean the synchronization of conditions which were not everywhere possible, and this rather made the processess lacking in flexibility. Moreover, their use was confined to coal of a particular class, so far as size was concerned. Coming to the second category, which he thought opened-up by far the best prospect for commercial exploitation, one could start with a comparatively low-grade fuel and up-grade that, and sell a product, which was mainly semi-coke that the ordinary housewife might be willing to buy for domestic fuel. Any estimate based on the prospect of getting a higher price than that charged for ordinary coal, however, was bound to be wrong, because in the long run, so far as domestic coal was concerned, it was the woman who managed the purse, and it was doubtful whether housewives would be willing to pay more for this new fuel than for ordinary house coal. With regard to the third class—those processes using pulverized fuel—there, again, they were faced with a very real difficulty. If it were possible to synchronize conditions so that the powdered fuel could be used on the spot where it was made, then it would probably lead to the successful exploitation of processes of that kind; but where the pulverized fuel had to be transported distances in order to be utilized, the loss was likely to be quite considerable, and he did not know whether this loss had been taken into account in any of the balance-sheets which had been published. Personally, he had not noticed that this had been done.

SHAREHOLDERS WITHOUT DIVIDENDS.

But looking at these processes as a whole, the remarkable thing to him was that he could not remember any one of them having yet paid a dividend, notwithstanding the fact that processes of one sort or another had been before the public for twenty years; and it went without saying that the only people so far who had made money, or who appeared likely to make money, out of these processes were those who dealt very largely in shares. When he said that no dividend had been paid, he meant dividend as the result of selling the products (whether coal, semi-coke, oil, or gas) and distributing money made over the working expenses in the way of dividends to shareholders. Probably twenty years was rather an early time within which to expect dividends to be paid; but he did not think it was unreasonable to expect that some of these much-belauded processes should have distributed a little to the shareholders within the past few years.

Then attention ought to be directed to this point. No doubt from the national point of view it was vital that in times of stress the Navy particularly should have some source of oil which it could rely upon, because they knew from bitter experience during the last big war the position likely to arise. It was probably a fair figure to say that 15 gallons of oil per ton might be expected on the average from the carbonization of coal in these processes. This might be a high figure; but it very much depended upon the coal and the process. Not very much oil was obtained, when the matter was looked at on the basis of national safety, from the carbonization of 1 million tons of coal; and to make themselves feel comfortable so far as the Navy was concerned, he would rather like to visualize the carbonization of 20 million tons of coal per annum. Further, he did not think it was unreasonable to assume that, taking working capital into consideration—and this was a thing which many people forgot all about—the capital cost of these processes would be roughly £1 per ton of coal carbonized per annum, to provide for working capital as well as plant; and therefore it would run into large figures before they knew where they were. He might have been taking a pessimistic attitude so far; but looking at this problem broadly, he felt quite frankly that there was not such a tremendous future for low-temperature carbonization—or high-temperature carbonization, for that matter—as the public Press seemed to imagine. If he said nothing more than sufficient to make this corrective, he would be satisfied. At the same time, he believed that here and there, if care was taken, a suitable process might be developed locally, where conditions were favourable; and in such circumstances it should be possible to return a fair dividend on the capital invested. They knew, also, that there were certain fuels which were not marketed very readily, because they would not stand rough handling, or because the public would not buy them. It was an admitted fact, however, that some of these processes rendered such fuels capable of being marketed. Captain Sinnatt's review of present knowledge of low-temperature carbonization was most useful from every point of view; and he was to be congratulated on the fact that he had taken an impartial, non-committal attitude. He could well imagine also that the proper phraseology of the paper must have caused the author a good deal of thought during the two anxious months to which he had referred.

CARBONIZING AT THE FURNACE MOUTH.

Prof. A. W. NASH (University of Birmingham) said he was not really interested in whether low-temperature carbonization had been profitable or not. He had come neither to praise nor condemn low-temperature carbonization, because, though he had followed it now since 1913, he felt that they knew very little about it, and that it was difficult to make dogmatic statements regarding either the processes or the products. He congratulated the author on the excellent review of the position he had given, and had been struck by the modesty of the contributors to this review, because he certainly expected to find much more extravagant claims than had been made, though some of them seemed to be guided largely by optimistic hopes. From what aspect should they consider low-temperature carbonization? First, was it to improve the state of the coal industry? He believed that Dr. Krauch, in Germany, recently stated that if all the oil required in that country were produced by the various methods of production of oil from coal, it would represent an increase in the coal production of that country of 2 p.ct. One of his own colleagues, Mr. Graham, had worked out a similar figure for this country, which he placed at 6 p.ct. Personally, he considered that the coal industry would benefit more by the wider use of pulverized fuel, because if coal were powdered it became as mobile as liquid fuel and could be burned much more efficiently than in the lump form. Secondly, was the idea to provide a substitute for mineral oil, and, if so, when? During times of peace? Then he thought the wrong time had been chosen, because at the present moment the world was producing much more oil than it could dispose of, and prices were so low that there was very little hope of competition. If it were to produce smokeless fuel; had they not already a smokeless fuel in the form of gas? If it were to produce intermediates for the pure chemical industry, this was a subject which he could not discuss, but it was one which would prove of very great interest to everybody. Dr. Cullen had remarked upon the difficulty of disposing of the gas and smokeless fuel in certain proportions, and he also had this point in mind, though he was not so much concerned with the gas as with (say) 15 to 20 gallons of liquid fuel and 15 cwt. of solid fuel. There was one point which occurred to him as the result of Young's work in Scotland with the original torbanite. Young paid 2s. 6d. a ton for his torbanite when he first started operations; but after two or three years the people who had the supplies of this material under their control discovered that it had a value, and Young was eventually compelled to pay 42s. 6d. per ton for his raw material. This more or less killed the process. He wondered whether this was likely to occur in connection with low-temperature carbonization. There was a statement in the paper to the effect that there was promise of a low-temperature tar fraction being found suitable as a lubricant. He would like someone to define what were the promising indications of a lubricant, and if those so-called lubricating fractions had been tested on a friction machine at high temperatures in an oxidizing atmosphere. Another point of interest was that the calorific value of low-temperature tar was about 80 p.ct. of that of fuel oil. Was it suggested that the purchaser of fuel oil was going to be as foolish as the purchaser of solid fuel had been in the past, and buy his fuel solely on weight? He felt sure that the consumer would want to buy it on calorific value, and not on weight—as coal should be bought at the present time—and this was going to reduce the value of the fuel as such. It had been suggested that the liquid fuel products from low-temperature carbonization fetched higher prices than fuel oil.

He sincerely hoped they would if they contained the motor fuel fraction. If, however, the fuel fraction was being compared with fuel oil, he was afraid the hopes of higher prices would not be realized. With regard to times of stress, Dr. Cullen was correct when he stated that our greatest difficulty in war-time would be to obtain liquid fuel for our fighting services. He was sure that if for patriotic reasons people were inclined to invest their capital in such projects, it was a very noble object; but there was one system of low-temperature carbonization which he himself had advocated for this purpose in one of his own papers on the subject—viz., carbonizing at the furnace mouth. Was it not possible for some of our large power plants to carbonize at the furnace mouth, where optimum conditions were not so essential as they would be in the case of a carbonizing plant proper? In carbonizing at the furnace mouth it did not matter if there were only 8 gallons or 10 gallons of liquid product per ton of coal, because there would be the permanent gas and semi-coke to burn in the plant as fuel; and if this were pulverized, the increased efficiency obtained would more than make up for any losses which might be incurred in regard to the volatile matter. This raised another point—viz., that if they were to regard these low-temperature carbonization processes as of value nationally in times of stress, then he would like to suggest that it was not so much the man in the street, who probably did not know a great deal about the subject, who should put his money into such processes, but the Government itself.

HIGH CAPITAL COSTS.

Mr. R. RAY spoke as a member of the staff of a firm who had tackled this question many years ago unsuccessfully. As far back as 1910 his firm went into this subject on their own initiative, and they were interested in it mainly from two points of view—first, the solid fuel for blending with their high-volatile coking coal; and secondly, and more particularly, on account of certain oil fractions. Dealing first with the solid fuel, Mr. Ray said this must have certain definite selling points. It had to face cheap coal in the mining industries in the first place; in the second place it had to compete with costly coal in those areas some distance from the coalfields; and in the third place it had to have a very definite physical standard. He doubted very much if low-temperature fuel would ever make much headway in the mining areas, for several obvious reasons. Perhaps the most important was that most of those who were employed by collieries and who formed the bulk of the population in these areas got cheap coal. In areas distant from the coalfields, low-temperature fuel must be sold at a price under the price of best house coal; and in order to get to these areas it must have sufficient physical strength to withstand the wear and tear of transport. In his own experience of low-temperature carbonization—he might be showing his ignorance—the idea had been in the past to charge a figure over and above that asked for household coal; and, secondly, the fuel itself had not stood up satisfactorily to the wear and tear of handling and transport. Again, if this fuel was to make headway against coal and the other smokeless fuels on the market it must be clean. If the initial coal was cleaned, it would naturally put up the price of the final product. Then again there was the question of the capital cost of the plant. If they started with a costly raw product, and the capital cost of the process was out of proportion to the capital costs of other coke or semi-coke producing plants, this must be a distinct handicap; and he submitted, as a matter of fact, that the capital cost of any low-temperature plant (of comparative capacity) to-day was out of all proportion to the capital cost of coke oven plants or gas-works producing satisfactorily a smokeless fuel. The same thing applied to low-temperature powdered fuel. In his opinion powdered fuel could only make headway for some years to come at or near the centres of coal production. Unfortunately for low-temperature enthusiasts, there were abundant supplies of natural powdered fuel of an inferior quality, which was a curse to those managing coke ovens. In the wet washing process a slurry was formed containing a high percentage of moisture and dirt; while as regards dry cleaning processes, with all respect, he stated that there was not a process which would clean fine coal under $\frac{1}{16}$th mesh. Therefore, this fine fuel was thrown on the hands of colliery managers, and utilized in their powdered fuel installations. Thus semi-coke and low-temperature processes had an uphill and difficult road to climb if the attempt was to be made to compete with natural powdered fuel. He submitted that it would be impossible in the colliery areas, in any case. As regards blending, there were distinct possibilities; once again, however, if it were to be successful as a blend, low-temperature fuel must essentially be cheap and also clean. He had already suggested that if this fuel was to be successful as a market, it must be clean, and therefore fairly costly; and if it was fairly costly, those on the coking side could not consider it for blending with normal coking coal. His firm was also essentially interested in the liquid fuel side of the problem; and though his previous remarks may have appeared to be somewhat critical and pessimistic, he was really optimistic in that he believed, from what Captain Sinnatt had said, that in the near future there was some hope for a definite and valuable liquid product. His firm were interested in the phenols; and it was with this object in view that his Company originally undertook various investigations into the low-temperature problem. Unfortunately the expressions of opinion regarding the phenolic fractions of low-temperature oils had been decidedly vague. The term phenol embraced a tremendous number of fractions. To-day the lower fractions boiling between 190° and 210° C. were more or less a drug on the market. They could be obtained everywhere; but for certain disinfectants where phenols with high boiling-points were essential, the present position was far from satisfactory. Especially was this so two years ago during the general stoppage, when high-boiling phenols were at a premium, and could not be obtained in this country. Therefore he would like to ask a direct question—viz., what did the phenolic fraction between 210° and 260° C. amount to in the oils which had so far been examined? What about the capital cost? As he understood it, the promotion of each individual low-temperature process made the statement that a plant with a high throughput was actually working at the present time. What did that mean, and what was this high throughput? Many knew that he had an unfortunate reputation for running down the small throughputs of coke oven plants. He was supposed to jeer at 300 or 400 tons a day. He had placed his figure at a minimum of 1000 tons per day, and very much preferred to put it at 1500 tons per day. As far as he could gather, however, low-temperature plants were confined to 10 tons, and only in one or two cases to 100 tons, per day. The capital cost of such plants was high and their throughputs low. How could they, therefore, even with a large number of units, ever hope to compete either on the solid or liquid side of the question when they were up against coking plants—and modern coking plants did produce a satisfactory freely-burning domestic fuel. As one definitely interested in the solid fuel from the point of view of blending, and still more definitely interested in the liquid fuel from the point of view of disinfectants, perhaps he would not be out of order if he offered his best wishes to the experimenters in low-temperature carbonization research.

SMALLER GRADES OF COAL IN DEMAND.

Mr. H. EUSTACE MITTON, in a written communication, said the paper was of great importance, inasmuch as it dealt with a subject which to-day was constantly before the mining engineer. Coal, as raised from the mine, naturally varied in size from large lumps to fines. Prior to 1914, with the exception of the companies who fortunately possessed seams of a coking character, the marketing of the smaller grades depended on the cycle of trade; and it was the practice to allow stocks to accumulate, and dispose of them, when opportunity afforded, in their raw condition. During the war period, great activity took place; and with the attraction of obtaining oil from fuel, many companies spent large sums investigating low-temperature carbonization with this end in view. To-day, due to the change in the old order, the open-grate hearth was rapidly disappearing. With the substitution of oil for creating power, electricity for heating, and gas for cooking, the coal owner was faced with the position that where formerly the lump coal was in demand, to-day the smaller grades were sought for. To give an instance of this, he might refer to a large company in the Midlands, where the coals were of a non-caking character in the bulk supplies. The demand was very good for the smaller grades; but due to the lack of demand for the lump coal, it naturally followed that stocks of this class prevented the full-time working of the colliery. The author truly said "the natural result will be an increase in price of the small coal until it bears its mining cost." This was bound to come, as if one could get the same value from fine coal there was no attraction in paying a considerably higher price for the article simply because it was in a different form. What the coal owner had to realize was, that he must deliver to the consumer the coal he was buying on its calorific value, free from dirt; and the consumer must realize that if he acquired the coal in a form that suited him, then he must pay the price consistent with what he required.

COST OF THE SMOKE NUISANCE.

Mr. R. H. CLAYTON said many of the matters that had been raised in the discussion seemed to him beside the point; the real consideration being how the country would benefit from taking up low-temperature carbonization. He had been connected with the smoke abatement movement for thirty years; and in visualizing a process of this nature, one must consider, not only the cost of the manufacture of the fuel, but the money the country would save by the adoption of a fuel suitable for domestic purposes. He had spent considerable time on committees investigating what the country might save by having smokeless cities; and it had been estimated that the cost at present to the country of the smoke nuisance was at least £1 per head. Personally, he thought it was very much more; and the Manchester Air Pollution Advisory Board, of which he was a member, gave figures greatly exceeding £1 per head. If a process of this sort could produce a fuel which would be accepted by housewives, he claimed that the object of low-temperature carbonization had been attained. Even if such a fuel were produced and given to the housewife for nothing, the country as a whole would save money, owing to the damage now done as the result of using ordinary coal in domestic grates. This was a point of view to bear in mind; but it could not well be put forward on a balance-sheet. It would, however, be one which would induce the public to put money into low-temperature carbonization schemes, if they had at the back of their mind a fuel which would give a smokeless city. It always seemed a pity that only so small a number of people in England were conversant with Continental conditions. When one went abroad, and visited cities where houses were heated on the central system, and saw the happy surroundings in which the working-classes lived, it was sufficient to create enthusiasm for low-temperature carbonization or any process which would give pleasant cities to live in. Personally, he believed that a great deal of industrial unrest was reflected in the very filthy conditions in which many of the workers in this country were living. The reference to the future price of small waste coal was very apt. When bye-product plants were originated in this country, slack was practically an unsaleable commodity, fetching 1s. or 2s. per ton at the pit. The adoption of the bye-product recovery oven put these low value slacks up to a high figure. In regard to oil production, he presumed that this was largely of a paraffin character; and while benzole was sold at 1s. per gallon, and only 25 p.ct. was added to ordinary petrol to get an anti-pinking spirit, he was wondering whether the benzole recovered from low-temperature fuel would have the same value, and whether an addition of 25 p.ct. to petrol would give the same anti-pinking properties. If it had not the same anti-pinking value as the present quality of benzole, the price would have to be low. With regard to tar products, a great many of the bodies which the author had mentioned existed in coal tar. Already many of these products had been separated, such as the methyl-naphthalenes, &c.—but it had not been possible to find a ready market for them, and there needed to be a sufficient output to

cut any ice in the matter of returns per ton. The pitch question was one upon which there were doubts in his own mind. The pitch obtained from a great many of these processes would not be suitable for road work. It was far too elastic, and lacked the free carbon which was necessary to give a good road tar. This could be overcome by de-hydrogenation, which was, however, an expense, and would put up the cost of the finished product. The main point, as he had already mentioned, was the omission from balance-sheets relating to low-temperature carbonization processes of the value of them to the nation as a whole.

NEED FOR ENCOURAGEMENT.

Colonel W. A. BRISTOW said he was glad to see that this matter was being discussed in a much more scientific spirit, and more openly than was usual in discussions of this nature. The criticisms that had been made in regard to the long time that it took to develop these processes, were to a certain extent justified; but it also followed that where it took a long time to perfect a technical process, it must necessarily take a long time to get adequate financial reward from it. However, where that process was directed towards a solution of a great and very serious national problem, everybody should give the utmost possible encouragement to the continuity of the work, and should not in any way damn the efforts being made by criticism of a merely destructive character. The vast issues which were raised by the whole question of the utilization of coal deserved the most serious consideration of everybody engaged in this industry; and conferences such as this would be of the utmost value, if only they brought on to one plane all those who approached the subject from different angles, and thereby secured a certain amount of good-natured co-operation which otherwise the subject did not receive.

The author had stated that it was difficult to discuss the low-temperature carbonization process from its value to gas companies. Personally he did not agree with this. The low-temperature carbonization process, as he saw it, was primarily useful for the manufacture of smokeless fuel; and it was upon this point that the attention of his Company was focussed, and one from which they did not intend to deviate. The object of a gas company was to manufacture gas; and the whole of the apparatus and process was necessarily directed towards making the utmost possible quantity of gas at the lowest possible figure. The object of his Company, on the other hand, was to make the largest quantity of smokeless fuel of the right kind, chemically and physically, at the lowest figure. It was possible for the gas company to harness low-temperature carbonization to their ordinary work; but this was another matter. The gas undertakings were in the best condition to utilize the rich gas made by the low-temperature carbonization process, and they were, therefore, able to kill two birds with one stone by putting down plant, because they would at the same time produce a more suitable smokeless fuel than at present. Whether, however, the process was of any use to a gas company or not did not in any way affect the object which his Company had in view—viz., to provide the country with a smokeless fuel by means of low-temperature distillation of coal.

The paper mentioned that most of the processes, or all of them, claimed to have a throughput of 10 tons per day. Whether this was correct with regard to all of them, he did not know; but since his Company started in July last the sales of the smokeless fuel had steadily increased, and at present they were distilling over 200 tons of coal per day. The actual sale of "Coalite" throughout the country was over 1000 tons a week. There was no doubt that within a short time—a matter of weeks—the Company would be able to sell not only the whole maximum possible output of the present works, but of two or three other works in addition. It was true that certain processes which the author mentioned had proved their claims; but he knew of two or three which had been mentioned which had only proved their claims in respect of experiments carried out in an apparatus about the size of a washhand basin. When these processes came to be translated into dealing with 200 or 300 tons of coal per day, it would be a different story.

He agreed with the author that it would be fatal to the chances of any smokeless fuel if it depended upon having the grates of the country altered to accommodate the new fuel. The fuel produced by his Company's process could be burned in any type of grate, open fires, closed fires, anthracite stoves, boilers, and any other place where coal could be burned. It ignited readily by the agents used to ignite coal; and there was no difficulty whatver in making a fire. He agreed with Dr. Cullen that many of the financial articles which appeared in the Press were wholly beside the mark. They offered the most alluring proposition to people to put their money into processes which never had been, and never could be, worked on a commercial scale, and whose only assest was a pious hope. It could not be too frequently reiterated that anybody could conduct low-temperature carbonization of coal.

Dr. Cullen, in dealing with the question of oil, had stated that 15 gallons would be the maximum possible amount obtainable per ton of coal carbonized. His Company, however, were obtaining regularly every week over 20 gallons per ton. He would like to cross swords with Dr. Cullen on the question of whether or not there was a future for low or for high temperature carbonization. It was admitted that 40 million tons of coal were consumed in this country every year for domestic purposes; and even if they took the quantity at 30 million tons only, they wasted, by burning that amount of coal, the enormously valuable asset in the bye-products. If it was a fact that these could be recovered at a profit, and if it was a fact that the country as a whole would greatly benefit by making the domestic fuel smokeless, then obviously there must be a great future for carbonization, whether at high or low temperature; and it was a problem in which the country must be vitally interested.

Prof. Nash had referred to the remark made in the memorandum which he had contributed to Captain Sinnatt's paper, and had suggested that the hopes there expressed for a higher price for oil obtained from this process were based on false premises. The price received for the oil did not depend, however, on the fuel oil content. It depended upon other constituents in the oil which were of far greater value; and though it was, of course, true that variations in the price of fuel oil would bring about variations in the price of that part of the oil, yet, on the whole, it would not affect the price very much. He was basing his hopes for an even higher price than was being obtained to-day for oil upon the fact that considerable research was going on in regard to splitting-up these oils, and marketing them. All the time there was a distinct improvement in the treatment of the oil and the marketing of the different products; and the prices would undoubtedly rise. To-day, the price received for the oil products from low-temperature carbonization were higher than they had been for several months, and certainly higher than those obtained for fuel oil.

Mr. Ray had stated that he very much doubted whether there would be any demand for low-temperature carbonization fuel in mining areas; but there was a gentleman present who was selling every week in Sheffield many hundreds of tons of "Coalite." This was sufficient answer to that question. When he was first in touch with the distributors in Leicester they told him that it would be impossible to sell "Coalite" there because they were in the middle of one of the best coalfields in the country; but to-day Leicester took large quantities of Coalite at 42s. 6d. per ton delivered to consumers' cellar. It was true that any residue from low-temperature processes was of no value from the smokeless fuel point of view unless produced in such a form that it would withstand the wear and tear of transport. This was one of the things claimed as a considerable asset in the case of "Coalite," which dropped from the retort in a size which needed no further breaking up, and withstood transport in such a way as to undergo minimum wastage and loss.

RADIANT EFFICIENCIES OF L-T AND H-T COKES.

Mr. M. BARASH said that the author had quoted the results of Bligh and Hodsman with regard to the radiant energy from low-temperature coke and had compared the results obtained with the results obtained from coal. While realizing that the paper could not cover all the possible information relative to the subject, it would add to the story if he himself gave a short account of the comparison between the results obtained with low-temperature coke and high-temperature coke as stated by Bligh and Hodsman in their paper. In this paper it was shown that the highest radiant energy obtained from the fires with which the authors were experimenting was obtained with high-temperature coke produced in an experimental plant; and the definite conclusion was drawn that the radiant energy of a fire burning coke was inversely proportional to the volatile matter in the fuel. In other words, with high-temperature coke containing practically no volatile matter, a higher radiant efficiency was obtained than with low-temperature fuel containing an appreciable percentage of volatile matter.

Captain Sinnatt had mentioned the fact that it was possible to ignite a low-temperature fuel with a ½d. fire lighter. About eighteen months ago at an exhibition in Manchester there was a "Peveril" grate adapted for gas ignition of coke, giving a most cheerful fire with ordinary high-temperature coke provided by the Manchester Gas Department. There were some grates on this principle, but further developed, at the British Industries Fair in Birmingham. In the case of the Manchester exhibit, the coke was high-temperature vertical retort coke, and the ignition took only five minutes by means of a small gas burner. The cost of this would compare favourably with the ½d. fire lighter. He thought a useful hint to the gas industry would be to encourage the use of gas and coke in this way, even though the quantity of gas thus required would necessarily be small.

Further discussion of the economic balance between low-temperature and high-temperature processes, was, perhaps, in the nature of "flogging a dead horse." The domestic value of coke depended to a very large extent on the radiant efficiency of the fire produced. From this point of view low-temperatre coke had already been shown to be inferior to ordinary coke produced by high-temperature processes. The next big item was gas. No low-temperature process could claim that the thermal yield of gas produced per ton of coal could compare with that produced in high-temperature processes. Thirdly, there was the question of the tar; and he had yet to see any real advantage, in both quality and quantity, as compared with the tar produced in high-temperature plants. Tar produced in the continuous vertical retort was of the nature of low-temperature tar, because it was mainly produced at the top of the retort, and did not pass through the hot zone of the retort, so that a minimum of cracking was experienced. Yields of 18 to 20 gallons per ton in steamed vertical retorts were common. A yield of 20 gallons of tar by a low-temperature process was claimed by the previous speaker. To-day, in conversation with a gas engineer with whom he had been associated last year over the question of tar yield, he had been told that 17 to 18 gallons per ton has been his average make for the last few months from medium gas coals in continuous vertical retorts. Considering all things, therefore (and particularly the gas yield), the balance appeared to be definitely in favour of high-temperature carbonization.

THE WHOLE COMPARISON A FINANCIAL ONE.

Mr. H. P. HIRD said the whole question of comparison between low-temperature and high-temperature carbonization resolved itself into a matter of £ s. d. In one of the papers read at the conference it was stated that gas produced by coke ovens was valued by town gas undertakings at a price of 3½d. or 4d. per 1000 c.ft. If one took the gas yield of a coke oven plant at 10,000 to 12,000 c.ft. per ton, the total value of that gas would not be a very high figure. It was known that in low-temperature carbonization there was a lower yield of gas, but of a higher calorific value. However, from the low-temperature point of view, there was a product—in addition to the coke, which it was claimed would fetch quite an equal price to high-temperature coke (in fact, he believed it would fetch a bigger one)—viz., oil. In his opinion this was a product which would yield a very big revenue to the low-temperature carbonization process.

The tars produced by high-temperature carbonization contained only about 3 p.ct. of tar acids; and anybody who was in the tar business knew that the product contained in tar which was of the greatest value was the tar acid fraction. By his own system of low-temperature carbonization, he could get a very high yield of the tar acid fraction, between 35 and 40 p.ct. He had gone through the figures which the author had given of the various yields of tar acids and low-temperature oils (Table V.), and found that when he added these figures, by taking the oil distilling and the tar acid content which was at the bottom in each case, the percentage was 100, *plus* the tar acid content. This showed that these low-temperature oils had been distilled, and then the tar acid fraction had been separated from the oil. If the tar contained, for example, an average of 50 p.ct. of pitch, the amount of tar acid in the low-temperature oil would be only half the figure stated. Turning to the figures given by himself of the Hird process at the end of Captain Sinnatt's paper, it would be seen that, with a Durham coal, there was 38 p.ct. of tar acids.

Extracting the Tar Acid Content.

As regards the question of a commercial system for treating these low-temperature oils, he suggested that he was quite right, from his experience with them—on grounds that he could explain—in saying that with low-temperature oil it should be possible to extract the tar acid content direct with caustic soda, without any distillation. If the figures he had given at the end of the paper were gone through, it would be found that he separated the tar acid content from the neutral oil fraction. He was much surprised to find when he came to distil this neutral oil fraction that he could carry the temperature up to about 700° C. before it dried; and there was practically no pitch content. When he came to distil the tar acid fraction, he found that at 360° C. very vigorous cracking took place. The pitch started to form—although it really could not be pitch, because it was soluble in the first place in caustic soda. It must be a high-boiling resin, or some product soluble in caustic soda which they did not know much about. It was necessary to wash with caustic soda for this reason: Supposing that oil was submitted to distillation just as it was received, when a temperature of 360° was obtained pitch formation started. He had also stated at the end of the paper that, in taking an oil up to dryness, he could distil oil from the neutral oil fraction up to 500° C., so that all the heavy oil above 360° up to 500° C., which he considered would be of value from a lubricating point of view, would be lost, as it would be left in the pitch. On the question of tar acids, he would like to add a few remarks on the point raised by Mr. Ray as to the boiling-point of these products. He had had a lot of experience in the manufacture of disinfectants, and had found that practically the whole of the tar acid fraction boiled-off at 200° C., and when a disinfectant was made it gave a co-efficiency of about 15 by the Rideal and Walker method. In that case, as Mr. Ray knew, these high-boiling acids fetched about 4s. per gallon; so that there was a product in low-temperature tar which, as Mr. Ray said, was very difficult to get in the required quantities, but for which a great demand existed, and for which 4s. per gallon could be obtained.

Prof. Nash had spoken of the value of low-temperature oil; and he would like to say in reply that low-temperature oil would never compete in this country so long as one could buy oil from the United States and other countries at about £3 per ton. Fuel oil in the United States was worth 1d. per gallon f.o.b. As a matter of fact, this country was supplying creosote oil to the United States, and obtaining 7d. per gallon f.o.b.; so that obviously creosote oil and oil products from tar had a wider field of application than fuel oils. Another point mentioned was the running of a low-temperature plant at the end of a furnace. One thing he had found with regard to low-temperature carbonization was that it could be run very well in conjunction with high-temperature plant. If the waste heat from the high-temperature ovens was available, it would be about the right temperature for running a low-temperature plant in connection with it. Therefore the fuel costs would be very small.

Comments on Various Systems.

Mr. John Roberts said that in his paper at the morning session he had already given his view as to the prospects of producing semi-coke under high-temperature conditions; and he would not touch on that aspect of the matter now. At the same time, he was a lover and user of low-temperature fuel; and it was as the result of this experience that he wished makers would see that this fuel was smokeless. He was in the position of being "bunged up" with it in his cellar, but he could not take any body into his house to demonstrate the use of this fuel as a smokeless fuel; and this was unfortunate. Something had gone wrong with the process somewhere. He wished to arrest the wholesale condemnation of low-temperature systems, because he would prefer to examine the good points of some of them. For instance, a very remarkable fuel was being produced in the Sutcliffe system by Leigh Smokeless Fuels, Ltd. This fuel was suitable for use not only in the open fire and as a substitute for coke in the "Robin Hood" type of boiler, but also in anthracite stoves. Indeed, he suggested that the best outlet for such fuel, provided there was a market, was for use in anthracite stoves, where it would compete with a very expensive fuel, and ought to obtain a good price. Mr. Roberts said he was not interested either financially or professionally in any of the systems he was going to mention.

In the Illingworth system, which embraced a cute coke-cooling system, there were one or two points to which he would like to refer. Illingworth used a sort of cylindrical wagon in which the raw coal was charged. The wagon was placed underneath the retort, the hot coke was dropped into it, and the wagon was revolved. Meanwhile, the coke was being cooled and the moisture from the raw coal was being driven off. The fuel was separated over a screen, and the coal was put into the retort. The question he wished to ask was, What became of the water from the coal? He asked it as a prospective user. Further, what happened to any coal dust uncarbonized that might adhere to the smokeless fuel that had passed over the screen? Were they going to have the same trouble that he was having with the fuel he was using at the present moment in that it would not be smokeless?

The Turner process was also of interest, and it embodied one or two new features. He understood that the system employed superheated steam, which was passed through the charge of coal; and it was claimed by Mr. Turner that he could drive off the whole of the water in peat with less heat than was theoretically required to evaporate the moisture in the peat. Mr. Turner had told him this about 2½ years ago, and he still maintained that he could do it. Of course, it was impossible to evaporate moisture at the retort temperature with less than the theoretical quantity of heat. What happened in this case was best illustrated by reference to a pulsometer. When steam was driven down one limb of a pulsometer, the steam came in contact with cold water; but the steam was not immediately condensed. There was a hot film between the steam and the water, which protected the steam until the water had been propelled below the bottom of the outlet. Then this film was disturbed, and condensation took place. The water rose in that limb of the pulsometer, and the process went on in the other. What was happening in the Turner system, he believed, was that there were certain tiny globules of free water formed, and these became surrounded with a thin film of hot steam which protected the globule of water and prevented it being evaporated, so that altogether Mr. Turner did accomplish what he claimed. It was not, however, through the evaporation of the moisture, but by propelling the moisture through the retort.

Another process worthy of close consideration was the Hird process. Here there was an entirely new principle in operation. Many people had tried cast-iron retorts before, and had failed, and probably others would fail also. But, to begin with, Mr. Hird used a special cast iron which would stand a temperature very much higher than ordinary grey cast iron. Low Moor "cold-blast" iron was used which would stand 800° C. Having got that iron, Mr. Hird arranged that the volatiles of the charge to be carbonized passed inwards through the retort instead of outwards, as in other processes. Consequently, there was considerable economy in the matter of heat, and there was also the advantage of heating by convection by means of the hot products passing through the charge to the centre and up through the openings formed by the rotating rods. These main features were very promising, but again the proof of the retorts was in the heating; and they would have to wait until the retort had been seen in operation.

There were a few questions he would like to ask Colonel Bristow with reference to "Coalite"—viz., What was the amount of capital that had been expended and subscribed for the low-temperature plants which had been erected? What dividends had been paid, and what further capital would be required to develop the process? Another matter was that he understood that carbonizing was being carried out in tubular retorts. Were these tubular retorts those which were patented by Parker in 1907?

There were one or two other matters. Mr. Sinnatt stated: "Further, the work of Lessing and Cobb has indicated that it is possible to modify the properties of high-temperature coke and provide a product possessing greater activity; and this suggests a wider use of high-temperature coke for household purposes." Would the author give him the reference to that work? He always liked to acknowledge prior publications; and as he himself was writing a good deal on this subject, he would not like to ignore the work of Lessing and Cobb.

The author also stated: "The whole problem (preheating) was being studied on a semi-large scale by Prof. Wheeler, who has found it possible so to control the degree of oxidation of coal during preheating as to obtain from a coking coal during subsequent carbonization a semi-coke of any degree of agglomeration." It would be interesting to know if, when the author said that Prof. Wheeler had *found* that, he meant he had discovered it, or whether it meant that Prof. Wheeler had found it in the sense that a first-year student might find it if he carried out instructions which were to be found in a text-book. As he had stated at the morning session, the oxidizing system was first developed at the low-temperature works at Barnsley.

The Chairman said he did not think the questions which Mr. Roberts had put to Col. Bristow ought to be dealt with at such a conference as this; and he would take it upon himself to ask Col. Bristow not to answer them now.

Low-Temperature Carbonization must Stand on Its Own Feet.

Dr. S. R. Illingworth said that the position with regard to low-temperature carbonization was that it was competitive, and must stand on its own feet. If it were to be regarded as the spoiled child of carbonization—if it could not earn its own living—it would have to go on the "dole." Personally, he hoped the dole would soon be out of action; and therefore low-temperature carbonization would either have to stand on its own feet or go out of use altogether. Certain people, of course, were wanting to do things in a few minutes, but Von Baeyer took thirty years to synthesize indigo on a commercial basis. Low-temperature carbonization must first develop on scientific lines—viz., the study of coal—secondly, on technical lines; and, thirdly, on commercial lines. The commercial basis meant the proof of the technical conception, and whether or not this would stand up to such practical considerations as capital costs, labour costs, maintenance, &c. The greatest was that the process must be capable of being worked by people not of a highly skilled nature; it must operate with more or less ordinary labour, and the plant must not need a glass case around it. In the course of his own activities during the past five years, he had been developing along these lines. At first he had fallen into the scientific investigation of coal and its carbonization in South Wales. Having covered the scientific ground, a small place was established for technical research alongside a coke oven plant at Pontypridd. Then he took over a section of the Pontypridd Gas-Works, because they were buying coke oven gas; and during the past four years there he had been carrying on certain activities with some colleagues, with the result that today he claimed that a commercial plant could be put up at under

£1 per ton—well under, as a matter of fact. Also, he was satisfied that the plant would stand up to its job; and he and his colleagues were not frightened of anybody coming down and seeing it. Low-temperature carbonization was not an "Open Sesame" to the solution of our coalfield problems. It was not a question of the re-organization of the coal industry; it was not a question of anything revolutionary. It was evolutionary; it had its place in the sun. In some districts it had a very definite place, and in others it depended on local conditions. In his own case, the conditions were that the plant was within ¾ mile of a colliery, and within the same distance of the coke ovens; yet it was possible to sell the fuel in competition with coal at pit-head prices. He was very fortunate in that he had people behind him jealous of their business reputation; they looked at the matter on a business basis. They were out to have a fight for success; and they were out to back their own opinions. His system of costing had been based on four years' working. The endeavour had been to design a simple plant; and he believed they had succeeded. He was not there to blow any trumpets, or anything of that sort, but to make a plain statement that these activities had been carried out and were going on, and to say to interested parties that every opportunity would be given to them to come and see the plant. Engineers could come down and carry out tests and run the plant themselves. He expected competition from high-temperature carbonization and from other low-temperature processes; but there was no one solution to any particular problem. In this matter he was not at all biased; and his policy was to live and let live. They must not expect miracles in five minutes, nor must they let everybody talk without having the bricks and mortar to show what they were doing. Carbonization in general was a national asset. There were people who desired to write "R.I.P." over all phases of this activity. Let us subscribe to that, not interpreting it as *Requiescat in Pace!* but "Research—Investigation—Progress."

DEALING WITH THE CRITICS.

Mr. ROBERT MACLAURIN said that Dr. Cullen had apparently spent most of his time examining balance-sheets. If he had spent more time studying carbonization, he would have been better able to discuss the problem. The same remark applied to Prof. Nash, who also was on the outside. It would be noticed that those inside with knowledge had a much more optimistic outlook on low-temperature carbonization than those outside. [Laughter.] At Dalmarnock, the strongest supporters of the process were in the gas industry; they were even more enthusiastic than himself. If Dr. Cullen and Prof. Nash were beginning *de novo*, they would not have had so many nasty things to say against low-temperature carbonization, or at any rate they would have had some more to say against high-temperature carbonization. In the Maclaurin process at Dalmarnock it was possible to make gas at a much lower cost than it could be manufactured in producers. He admitted that the gas was 240 B.Th.U., as against 400 or 500 B.Th.U. in gas-works; but on the basis of value, therm for therm, the low-temperature gas was the cheaper of the two. The gas could be produced in the low-temperature process at 1½d. per therm, and unless it took more than 1½d. per therm to distribute it, then the low-temperature gas was the cheaper. Again, with a low-temperature process, it was possible to send out a smokeless fuel which was easy to burn, and this was not the case with high-temperature coke. It had been stated during the morning that the consumer seriously complained of some of the high-temperature cokes sent out. In Glasgow, the merchants had on occasions sent out gas-works coke instead of Maclaurin fuel, and then something was heard about it from the customer. With the low-temperature process, he got a larger yield of oil; and during three months they had reached an average of 20·38 gallons per ton. Carbonizing similar coals in the ordinary way, it would not have been possible to get more than 15 or 16 gallons, and perhaps only 14 gallons. The ammonia product was equal in the two processes (low-temperature and ordinary verticals), but there were phenolic bodies in the liquor in the former case which could be taken out on a profitable basis. Further, the capital cost of the Maclaurin plant was lower than that of vertical retorts, and he could not agree with the suggestions that the low-temperature plants cost more than vertical retort plants. Depreciation charges and labour costs were also lower in the case of the low-temperature plant. He referred Dr. Cullen to these points, and asked him to reconsider his remarks.

Mr. Ray had referred to low-temperature coke as one which would not stand transport; but the fuel made in the Maclaurin process was hard, and would stand transport anywhere. The average crushing strength was 800 lbs. per sq. in. This material had gone through the blast furnaces successfully, and therefore it would stand ordinary railway transport. He held that the fuel must be clean. He used a coal which contained 5 p.ct. to 6 p.ct. of ash, and the final fuel contained 8 p.ct.; the fines which were separated out containing from 20 to 36 p.ct. of ash. Mr. Ray had asked a definite question as to the phenol content of the oil—namely, What was the percentage of high boiling-point phenols, between 210° and 260° C.? In a paper read by Mr. McLeod at a recent conference it was stated that the quantity of tar acids contained in the Maclaurin tar was 41 gallons per ton of tar. The quantity of tar acids contained in the tar from the narrower coke oven was only 0·14 gallon, so that there was a tremendous difference in the quantity of tar acids obtained from the two types of tar. Coming to the quantity of tar acids distilling between 210° and 260°, the figures were 24 p.ct. at 210° and 85 p.ct. at 260°, so that between these two extremes, 61 p.ct. of the tar acids came over. He did not think there was any tar acid that would equal that.

Continuing, Mr. Maclaurin said he accepted everything that Mr. Hird had said. The oil from the Maclaurin process was not sold in competition with fuel oil, but it was sold as creosote oil. It was sent to America, and it was taken there because it was better than they could get on the spot. It fetched a higher price than the oils which the Americans sent over here. An interesting point had been raised by Prof. Nash with regard to lubricating oils. Little work had been done on lubricating oils obtained from low-temperature processes. In 1916 he tried to do something of the sort at Port Dundas with a Thurston friction machine. The oil was separated by treatment with dilute acid and washing out the phenol. It was mixed with paraffin, and was tested in the Thurston machine against sperm oil, and it ran with a durability of 85 minutes against 68 minutes for sperm oil; the testing machine running at 2000 R.P.M. The remarkable thing about the oil from the process so tested was that on no occasion during the test did the testing machine run on the second day at a higher temperature than when the test started, whereas this could not be said of the other oils tested. Immediately on starting on the second day with mineral lubricating oils, the temperature ran up rapidly, indicating that resinification had taken place.

PLANT AT LEIGH.

Mr. E. R. SUTCLIFFE said that his process consisted in first making a briquette without a binder, and then carbonizing it in a vertical retort, or, alternatively, using non-coking lump coal which could be passed through the retort without swelling. One plant had been erected at the Leigh Smokeless Fuels Works, Leigh, to deal with 100 tons a day; and they were therefore well beyond the suggested 10 tons a day limit. As a matter of fact, some 3600 tons of coal had already been put through the retorts on this process. The smokeless fuel obtained was undoubtedly good. Mr. Roberts had had experience of it, and had mentioned it in his remarks. Quite a lot was sold for use in anthracite stoves, for which it was admirably suited. The tar obtained was of the low-temperature type. One speaker had asked how it was possible to get lubricating oils in the Leigh plant in an oxidizing atmosphere. The atmosphere was not an oxidizing one, because the carbonizing medium was the sensible heat of gas or steam that was passed through the retort. An analysis of the gas produced in the retort at various times showed a nitrogen content of 0·81, 0·44, and 0·5 respectively, so that, apart from the oxidizing effect of CO_2 or steam, there was practically no oxidizing effect from air leakage into the retort. He had listened to the discussion; and in view of the increased price which small coal would command, and the glut of phenols which would result as their efforts succeeded, due to the increasing number of plants installed, he thought it would not be possible economically to dispose of the solid product, unless some law was introduced forbidding the use of smoke-producing fuels. He asked Dr. Lander whether it was not time now to approach the authorities with a view to getting something done in this direction. He would say that not all were in this business merely for making profits out of share transactions. In the case of the companies in which he was interested, he did not believe there had been a single share transaction. Those interested with him believed this was a movement which ought to be developed in order to get away from those conditions existing in the country at present.

STAGES OF PROGRESS.

Dr. C. H. LANDER (Director of Fuel Research) said low-temperature carbonization would have to go through the same stages of development as had every industrial process. As a matter of fact, it was definitely going through the stages at the present time. The first stage was undoubtedly one in which a few grammes or a few pounds of material were tried out in the laboratory. Having proved that the products were procurable, the next stage was usually to try out the process on a slightly larger scale, but still not in a unit of a commercial size. A small retort capable of dealing with a few cwt. per day would be erected, and assuming that stage was successfully overcome, then they came to the third stage—the trying out of the process on the full-sized unit scale. Here he would like to cross swords with Mr. Ray and also Colonel Bristow, because they both referred to the same point—the unit of size. Mr. Ray was not comparing like with like when he spoke of 1500 tons a day for a coke oven plant, because Mr. Ray did not mean to carbonize that quantity of coal in one unit. He was referring to a bench, which was a collection of units. Colonel Bristow had stated that some of the processes which had been tested by the Fuel Research Division were of the size of wash-basins. Well, what if this was true. In the case of Colonel Bristow's own process, which was tested, and the technical claims for which were substantiated, they had tested 32 wash-basins simultaneously, instead of one or two. Anyway, having got over the third stage or full-scale experimental plant, there came the final stage of trying the process out on a battery (say) of 100 tons—ten 10-ton units, or something of that sort. The object of this, of course, was to get oils and fuel in bulk, and sell them; and it was only really then that one began to get hold of true commercial information. Low-temperature carbonization was going through these stages. Some processes were in one or other of the stages, and there were certainly several which were getting to the point of stage 4, if they were not at the end of it. There was just one point with regard to low-temperature carbonization to which he would like to refer—viz., the production of oil in time of national emergency. Even if the whole of the coal at present untreated were to be carbonized, it would not produce anything like the quantity likely to be required.

Of course, if some could be obtained, it would all go into the pot, and help. There was one, perhaps, discordant note he would touch upon, and he did it deliberately because Captain Sinnatt could not refer to it. It related to a short letter from Mr. Harald Nielsen, of the "L & N" process, and to a certain controversy which Mr. Nielsen appeared to think he had got with Captain Sinnatt, who, no doubt Mr. Nielsen genuinely thought, was guilty of want of courtesy in not answering certain questions which had been put to him in the public Press. Mr. Nielsen was probably not aware that no public servant was allowed, in any circumstances, to take part in newspaper controversy; and therefore it was quite impossible for Captain Sinnatt to make any reply to the questions that had been put to him in the Press. Such conferences as this were the place for this to be done; and if people could not come to such a conference, and put their questions, what was the use of the conferences?

The CHAIRMAN said that Captain Sinnatt had indicated his desire

to reply in detail to the discussion, after he had had an opportunity of studying what had been said. It would be agreed by all, he continued, that the author had had a very delicate task in preparing the paper. There were many interests involved; but he certainly had shown the most scrupulous fairness all through. He wondered if the audience would be inclined to agree with him that a true description of the state of affairs in regard to low-temperature carbonization would be that the people who started-off thought it was going to be an Eldorado, and got their fingers rather badly burned, but that those who were at present developing it had been working harder and more scientifically and systematically, and were really showing signs of a much more hopeful future, because the difference in the trend of the early and later stages was remarkable. Prof. Nash and Dr. Cullen sounded to him as if they had "dropped a bit" themselves. [Laughter.] Though he did not wish to be rude. He thanked everybody for the courteous manner in which the discussion had been carried on.

SIR ARTHUR DUCKHAM'S REPLY.

(*Vide p.* 133.)

I have read with considerable interest the important discussion following my paper, read by Dr. Smith in Birmingham on Feb. 24. The outstanding point made by all speakers was the necessity for improving the sales of coke. Much has been done, but much more can be done. In certain areas, where the gas undertaking has appreciated the value of coke sales, a good market has been developed, and continued endeavours are being made still further to improve the quality of the coke. The trouble is that gas undertakings or coke manufacturers do not take similar trouble; and those responsible in an area may have their good work seriously jeopardized by the dumping of unsuitable fuel from outside sources. It seems to me of paramount importance that, so far as gas undertakings are concerned, they should all agree to use every effort to sell their own coke in their own areas, and that, further, they should undertake not to sell their surplus coke in other areas except that surplus which has been properly graded and made suitable for use.

The sale of coke has almost as great an effect on the finance of a gas undertaking as the sale of gas. The greater part of the calorific value in the original coal is represented in the coke sales of an undertaking, and the burning of coke has as important an effect on the well-being of any city as the burning of gas. Might I, therefore, strongly press that the present area associations dealing with the sales of coke should be strengthened, and that definite regulations be accepted voluntarily by the producers in such areas for the benefit of the whole industry.

Mr. Ruthven strongly stressed the necessity for a low ash content. In the past, many gas undertakings have not given sufficient attention to the cleanliness of the coal; price has been a too predominant feature. Up till quite recently, coal cleaning has not been prevalent so far as run-of-mine coal is concerned, but in the future, with the introduction of dry cleaning plants, it should be possible for gas undertakings to stipulate an ash figure, and to reject or to penalize deliveries of high ash content. Mr. Ruthven also pointed out that by a certain manipulation of mixtures and carbonizing times, solid fuels more easily ignitable can be prepared. Much remains to be done, but the lines indicated by Mr. Ruthven undoubtedly hold out great promise.

Mr. Stewart especially emphasized the selling of coke in the producers' areas. This I would again emphasize. Dr. Parker pointed out the necessity of arranging for small deliveries of coke. One can almost imagine a small bag of coke being left every morning with the milk! Many engineers and managers have had experience of paper bag sales; probably something on these lines could be reintroduced with advantage.

Dr. Smith brings out the importance of the coke market to gas undertakings. Coke has usually been regarded as a nuisance to engineers and managers, and it was at one time hoped that total gasification might do away with this troublesome product. We are to-day beginning to realize that coke is a necessity for the community, and that, by improving the quality of this product so as to make it readily acceptable to the housewife, we shall be rendering another great service to the community, and reaping financial benefits.

Mr. Watson points out that a considerable amount of work has been done. This is agreed and appreciated; but that much more work remains to be done is generally accepted. I would emphasize the necessity for really good coke salesmen who know the technique of coke combustion and can show industrial and domestic users how money can be saved and better results obtained with a clean, smokeless, sized fuel.

Mr. Ray's contribution to the discussion is interesting as coming from the coke oven side. Undoubtedly coke oven coke will invade the industrial and domestic market. Consequently, it is necessary to increase the demand for coke. Suitably sized and graded coke oven coke has advantages over the ordinary run of gas-works coke for certain purposes. It usually contains less ash, is compact, and is, further, practically dry. Its use for central heating stoves is increasing, and personally I have used this coke in open grates without trouble over a whole season. It would seem necessary for gas undertakings and coke oven works to get together in areas so far as coke for domestic and general industrial purposes is concerned. It would be bad if a policy of cut-throat competition were adopted.

Mr. Toogood makes the sound point of standardizing coke. The more constant the fuel is, the better service the consumer will obtain and the more satisfied he will be—or "she," as the case more usually is. There has been against coke a strong prejudice bred by the lack of consideration given to this important subject in the past. I trust that the future will rapidly break down this prejudice.

I appreciate the kind permission given to me to make these few remarks to wind up a most satisfactory discussion.

CORRECTIONS.

(*Mr. T. F. E. Rhead's Paper: See p.* 59.)

Table II.—In compiling this table the figures for the producer gas analysis (CO_2, 9·6 p.ct., CO, 20·5 p.ct.) were accidentally inserted in Column 3, instead of those for the waste gas. The true waste gas analysis on which calculations for heat contents were based was:

CO_2	12·6 p.ct.
O_2	7·6 "
N_2	79·8 "

Table IV. should read Table V.
Table V. should read Table IV.

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